DATE: April 25, 1996

TO: Sharon Kramer

FM: Phyllis Fox

RE: Comments on Limiting Factor Analysis

I have reviewed the April 1996 draft of the report, Assessing Evidence on the Importance of Various Limiting Factors on Selected Ecological Features of the Sacramento-San Joaquin Delta/Estuary ("Report"). My comments follow.

I. RANKING CRITERIA

A. Factor "A" Should Be Refined

A ranking of "A" is the strongest evidence of an effect from the four factors that were considered. First, this rank requires a "sufficient x-y relationship." (Report, p. 2.) However, sufficient is never defined and should be. Based on the text, many relationships which are truly questionable are cited as evidence for an "A" ranking. "Sufficient" should be defined as a statistically significant relationship ($p<0.05$) that accounts for the majority of the variability ($r^2>0.50$). If only a small fraction of the variability is accounted for by a relationship, even if it is statistically significant, then other factors are implicated as playing a major role. When this occurs, which is common for many of the A entries in the matrix, the x-y relationship is not strong evidence for a "possible population-level effect."

Second, this rank requires that a reasonable biological mechanism be postulated. In most cases discussed in the text, the biological mechanism is unfounded opinion. Unfounded opinion is not evidence of a "possible population-level effect." It also does not address the fact that an x-y relationship is not necessarily evidence of a causal relationship. This criterion should be refined to require a preponderance (>50%) of scientific evidence (rather than no counter example) that a plausible biological mechanism exists, and that scientific evidence should be cited.

B. Factor "AB" Should Be Refined

Both factors "B" and "AB" are essentially identical, except "AB" requires a "probable population-level effect." (Report, p.

2.) "Probable population-level effect" is not defined and should be. In most cases discussed in the text, probable population-level effect is unfounded opinion. The items that are classified as "B" could just as reasonably be classified as "AB," or conversely, the items classified as "AB" could be classified as "B." Objective criteria for identifying "probable population-level effects" should be formulated. I recommend two criteria for factor "AB." First, that two or more independent pieces of evidence demonstrate an individual-level effect. Or, second, that a statistically significant x-y relationship ($p<0.05$) exist between abundance and the factor of interest that accounts for less than 50 percent of the variability ($r^2<0.50$).

II. TOXICS

A. Striped Bass Should Be Classified As "A" For Toxics

Striped bass are ranked "AB" for toxics. The Report argues that the evidence is inadequate to meet the criteria for population impacts to any species (i.e., "A"), and states that there is "no direct evidence for population-level effect" to striped bass. (Report, p. 4.) However, based on the information presented below, the criterion for factor "A," namely an "x-y relationship of some aspect of the factor and population abundance, with a reasonable biological mechanism postulated and no counter-example," would appear to have been meet for striped bass.

Historically, a good x-y relationship between rice pesticides and the 38 mm striped bass index has been reported. Bailey and others correlated estimated in-stream concentrations ("EICs") of several rice pesticides against the 38 mm striped bass index for the period 1970-1988. They found that, individually, these pesticides accounted for 23-63 percent of the variability in annual recruitment of larval striped bass ($p\leq0.05$). Multiple regressions found that EICs of two pesticides, bufencarb plus either carbofuran, MCPA or ordam, accounted for 89 to 94 percent of the variability in annual recruitment ($p<0.01$). In contrast, a flow-export model accounted for only 16 percent of the variability and was not statistically significant ($p=0.29$).[1] Similarly, X2 accounts for only 35

[1] H.C. Bailey, C. Alexander, C. DiGiorgio, M. Miller, S.I. Doroshov, and D.E. Hinton, The Effect of Agricultural Discharge on Striped Bass (Morone saxatilis) in California's Sacramento-San Joaquin Drainage, Ecotoxicology, v. 3, 1994, pp. 123-142.

percent of the variability in the 38 mm index and X2 plus exports for up to 60 percent of the variability in the index.[2]

There is also supporting data that indicate that striped bass have been adversely impacted by toxics. Bennett and others found liver alterations in 26 to 30 percent of the striped bass larvae collected in the Delta in 1988 to 1990 and in 15 percent collected in 1991.[3] In 1988, two out of three samples collected from the Colusa Basin Drain were acutely toxic to larval striped bass and one sample from the Sacramento River at Rio Vista resulted in 31 percent mortality to larval striped bass.[4] In 1989, 11 out of 14 samples from the Colusa Basin Drain resulted in an average of 66 percent mortality to larval striped bass; two out of four samples from the Sacramento River at Walnut Grove resulted in 95 to 100 percent mortality to larval striped bass; and two out of four samples from the Sacramento River at Colusa resulted in 88 percent mortality to larval striped bass.[5] In 1990, 14 out of 15 samples from the Colusa Basin Drain resulted in an average of 84 percent mortality to larval striped bass. In 1991, nine out of 20 samples from the Colusa Basin Drain resulted in an average of 40 percent mortality to larval striped bass. In 1990, two out of three samples from the Colusa Basin Drain resulted in 73 to 100 percent mortality in striped bass embryos, indicating a failure to complete the normal embryo development and hatching process.[6] In 1990, 3 out of 27 samples from the

---

[2] A.D. Jassby and others, Isohaline Position as a Habitat Indicator for Estuarine Populations, Ecological Applications, v. 5, no. 1, 1995, Tables 2 and 3.

[3] W.A. Bennett, D.J. Ostrach, and D.E. Hinton, Larval Striped Bass Condition in a Drought-Stricken Estuary: Evaluating Pelagic Food-Web Limitation, Ecological Applications, v. 5, no. 3, 1995, pp. 680-692.

[4] H.C. Bailey, Response of Larval Striped Bass to Agricultural Drainage and Sacramento River Waters, August 12, 1988.

[5] H.C. Bailey, C.A. Alexander, and S.I. Doroshov, Toxicity of Water Samples from Colusa Basin Drain and the Sacramento River to Larval Striped Bass and Opossum Shrimp, University of California, Davis, Department of Animal Science, 1989, Table 1.

[6] Bailey et al. 1994, pp. 132-133.

Sacramento River at Rio Vista resulted in 50 to 55 percent mortality to larval striped bass.[7]

The Report argues that "spawning striped bass were formerly exposed to waters of high toxicity, but the reduction of that input failed to result in increased abundance of young bass, thus producing a counter-example of the importance of that toxic input at a population level." It is true that on-farm management practices have reduced the concentrations of some rice pesticides in the Sacramento River. However, the principal pesticide included in Bailey's analyses, bufencarb,[8] is not covered by the rice pesticide regulatory program, which includes only carbofuran, malathion, molinate, methyl parathion, and thiobencarb. Moreover, the peak concentrations of regulated rice pesticides measured in recent years are comparable to those measured in 1988 to 1991 when the above-cited studies were carried out.[9]

Further, the Sacramento River is still frequently toxic to fish, explaining why striped bass and other fish did not rebound after the implementation of the on-farm rice management program. Five out of seven or 71 percent of the samples collected between February 1995 and February 1996 above the Sacramento Regional Wastewater Treatment Plant discharge point resulted in 27 to 57 percent mortality to fathead minnows, one of the hardiest species.[10] Studies done by Bailey[11] and Foe and Conner[12] indicate that significant mortality to striped bass occurs when no fathead minnow mortality is observed. Thus, if the Sacramento River is still toxic to fathead minnows, it is highly probable that it is also still toxic to striped bass and other fish, even though rice

---

[7] B.J. Finlayson, J.M. Harrington, R. Fujimura, and G. Issac, Toxicity of Colusa Basin Drain Water to Young Mysids and Striped Bass, CDFG Administrative Report 91-2, 1991.

[8] Bailey et al. 1994, Table 4.

[9] J.M. Lee and N.N. Gorder, Information on Rice Pesticides Submitted to the Central Valley Regional Water Quality Control Board, Department of Pesticide Regulations Report, December 28, 1995.

[10] Aqua-Science, Summary of 1995-1996 SRWTP Ambient Toxicity to Larval Fathead Minnows, 1996.

[11] Bailey et al. 1989, Tables 1 and 2.

[12] C. Foe and V. Connor, 1989 Rice Season Toxicity Monitoring Results, CVRWQCB Staff Report, July 1991.

pesticides have been reduced. Therefore, while it may be true that toxicity has been reduced in the Sacramento River, it is certainly not true that it has been eliminated. No changes in management practices have occurred elsewhere (e.g., in the Delta or San Joaquin Basin) that would reduce toxicity of those waters.

Based on the foregoing, and particularly in light of the refinement in the definition of factor "A" in Comment IA, I recommend that striped bass be classified as "A" for toxics. Further, because pesticides account for a much higher percentage of the variability in the 38 mm index (89-94%) than any other variable tested (35-60%), toxics should be ranked as the number 1 factor controlling striped bass abundance, rather than habitat.

B. Neomysis Should Be Classified As "AB" For Toxics

Neomysis is given a rank of "BC" in the matrix, apparently because "bioassay results with *Mysidopsis* suggest a possible effect on *Neomysis*." (Report, p. 4.) However, there is field evidence of a direct toxic effect on *Neomysis*. The evidence, reviewed below, meets the criterion for factor "AB," namely "probable population-level effect of an observed individual-level effect but no x-y relationship to support it."

In 1989, 14 out of 18 samples from the Colusa Basin Drain resulted in an average of 66 percent mortality to *Neomysis*.[13] Similar results were obtained by DFG.[14] In 1990, 13 out of 28 samples from the Colusa Basin Drain resulted in 32 to 100 percent mortality in *Neomysis*. In the same study, three out of 28 samples from the Sacramento River at Rio Vista resulted in 32 to 45 percent mortality to *Neomysis*.[15] In 1991, 6 out of 22 samples from the Colusa Basin Drain resulted in an average mortality of 18 percent to *Neomysis*.[16] In a two year study between April 1991 and February 1993 in the San Joaquin Basin,

---

[13] Bailey et al., 1989, Tables 1 and 2.

[14] B. Finlayson, Acute Toxicity Tests on Juvenile *Neomysis mercedis*, DFG Memorandum to C. Foe, August 11, 1989.

[15] Finlayson et al. 1991.

[16] Bailey et al. 1994, Figure 6.

DFG reported significant mortality to Neomysis in 13 out of 93 samples, or about 14 percent of the time.[17]

C. Cladocera Should Be Classified As "AB" For Toxics

Cladocera are missing from the matrix, but are given a rank of "BC" for toxics in the text (Report, p. 4.). Instead, the matrix includes daphnia, which are ranked "B" with no explanation. Daphnia should be replaced by cladocera in the matrix and ranked "AB" based on the evidence presented below.

There is extensive evidence of direct mortality to cladocerans in the Sacramento Basin, San Joaquin Basin, and the Delta. A recent risk assessment of organophosphate insecticides concluded that in the San Joaquin River, concentrations of diazinon that are toxic to the most sensitive 10 percent of the arthropods (cladocerans) are exceeded 29 percent of the time in January, 66 percent of the time in February, 20 percent of the time in March, and 16 percent of the time in May.[18] These results generally agree with ambient Ceriodaphnia toxicity tests, which indicate that in the San Joaquin River, samples are toxic 38 percent of the time in January, 23 percent of the time in February, 34 percent of the time in March, and 23 percent of the time in May.[19]

In the Sacramento River, the risk assessment indicated that diazinon concentrations that are toxic to the most sensitive 10 percent of the arthropods are exceeded 4 percent of the time in January and 15 percent of the time in February. The lower percent exceedances in the Sacramento River are, in part, due to poor sample recoveries.[20] A two-year field study found that

---

[17] R. Fujimura, Memoranda to San Joaquin River Group Members, Department of Pesticide Regulation: Lab No. P-1426, November 6, 1991; Lab No. P-1425, November 6, 1991; Lab No. P-1532, February 23, 1993; Lab No. P-1534, March 22, 1993; Lab No. P-1539, March 23, 1993; and Lab No. P-1540, March 26, 1993.

[18] W. Adams and others, An Ecological Risk Assessment of Diazinon in the Sacramento and San Joaquin River Basins, Ciba Crop Protection Report, Draft, February 1996, Table 25.

[19] C. Foe, Insecticide Concentration and Invertebrate Bioassay Mortality in Agricultural Return Water from the San Joaquin Basin, CVRWQCB Report, December 1995 and C. Foe and V. Connor, San Joaquin Watershed Bioassay Results, 1988-90, CVRWQCB Staff Report, July 1991.

[20] Adams et al., February 1996, p. 17, 54 and Table 25.

receiving waters in the Sacramento Basin resulted in significant mortality (>30 percent) to Ceriodaphnia 19 percent of the time in April, 48 percent of the time in May, and 46 percent of the time in June. No samples were collected in January and February.[21] In another study of toxicity above and below major reservoirs in the Sacramento River Basin, it was found that waters resulted in significant mortality to Ceriodaphnia 14 percent of the time.[22] Both of these studies also reported significant reproductive impairment of Ceriodaphnia.

Ceriodaphnia mortality and impaired reproduction have also been observed in the Delta. Twenty-four Delta sites were monitored twice monthly between May 1993 and May 1994. Ceriodaphnia reproduction was significantly reduced in 35 out of 238 samples, or about 15 percent of the total. Samples collected from back sloughs and small upland drainages tested toxic most frequently.[23] Samples collected during seven rainfall events frequently resulted in significant mortality and reduced reproduction of Ceriodaphnia.[24]

D. Other Fish Should Be Classified As BC For Toxics

All of the fish species, except striped bass, chinook salmon and starry flounder, are ranked "C" for toxics in the matrix, which indicates no evidence or incomplete evidence of effects. However, there is ample evidence that ambient waters are periodically toxic to fathead minnows, a related species. Fathead minnows are generally less sensitive to contaminants than

---

[21] V. Connor and C. Foe, Sacramento River Basin Biotoxicity Survey Results: 1988 - 1990, CVRWQCB Staff Report, December 1993.

[22] V. Connor and L. Deanovic, Central Valley Regional Water Quality Control Board Basin Plan Metal Implementation Plan Development Project, Bioassay Results: 1991 - 1992, Draft, December 1994.

[23] L. Deanovic, H. Bailey, and D. Hinton, 1993-1994 Annual Report for the Delta Monitoring Program, Draft, 1995.

[24] H.C. Bailey, S. Clark, J. Davis, and L. Wiborg, The Effects of Toxic Contaminants in Waters of the San Francisco Bay and Delta, Report Prepared for Bay/Delta Oversight Council, 1995; K. Luhmann, L. Deanovic, H. Bailey, and D. Hinton, Delta Monitoring Study, Quarterly Report, December 1, 1994 to February 28, 1995, Prepared for CVRWQCB, 1995; and T. Kimball, L. Deanovic, H. Bailey, and D. Hinton, Delta Routine Monitoring, Quarterly Report, March 1995 - May 1995, Prepared for CVRWQCB, 1995.

other fish species.[25] If they are impacted, it can be reasonably assumed that other fish species would be as well. The fish species ranked "C" in the matrix should be reclassified as "BC" because, as discussed below, there is evidence of individual effects on a related species, fathead minnow.

In a two and one-half year study between March 1988 and May 1990 in the Sacramento Basin, significant mortality to fathead minnows was found in 30 out of 272 samples or about 11 percent of the total. Among these, 12 percent were toxic in April, 32 percent in May, and 12 percent in June.[26] Between February 1991 and September 1992, significant mortality to fathead minnows was found in 10 out of 79 samples, or about 13 percent of the total.[27] Between April and July of 1993, 8 percent of the samples resulted in significant mortality to fathead minnows.[28] Finally, as noted above, five out of seven or 71 percent of the samples collected between February 1995 and February 1996 above the Sacramento Regional Wastewater Treatment Plant discharge point resulted in significant mortality to fathead minnows.

In a two and one-half year study between February 1988 and June 1990 in the San Joaquin Basin, significant mortality to fathead minnows was found in 24 out of 268 samples, or about 9 percent of the total.[29] In the risk assessment discussed above, concentrations of total organophosphate insecticides (expressed as azinphos methyl toxic equivalents) were toxic to the most sensitive 10 percent of the fish 4 percent of the time in the San Joaquin River.[30] Toxic concentrations would occur much more frequently on a monthly basis.

---

[25] Adams et al., February 1996, Tables 7, 8, 10, 11, 14, 15, 18.

[26] Connor and Foe, December 1993.

[27] Connor and Deanovic, December 1994.

[28] H.C. Bailey, C. DiGiorgio, L. Deanovic, and D.E. Hinton, Master Contract, North Valley Study, Quarterly Report, March 25, 1994.

[29] Foe and Connor, July 1991.

[30] Adams et al. 1995, Table 28.

E. The Classification Of Delta Smelt And Longfin Smelt With Respect to Organics Is Unfounded

Delta smelt and longfin smelt in the matrix are ranked as "0" for organics, apparently because their abundance was inversely related to diazinon concentrations in 1993 and 1994. (Report, p. 5.) This is not evidence for no effect. Delta smelt and longfin smelt should be classified as "BC" based on the discussion in Comment IID.

First, the cause of mortality to fish discussed in Comment IID above is unknown. However, it is probably not diazinon based on the diazinon risk assessment. The concentrations of diazinon that occur in the study area are much lower than the LC50s of fish.[31] There are hundreds of other contaminants that individually or together may be responsible for fish mortality. Therefore, the lack of a direct correlation between abundance and diazinon, which one can reasonably anticipate to not be toxic to delta smelt and longfin smelt, is not evidence of no effect from organic contaminants.

Second, it is not reasonable to assume that organic contaminants in general are correlated with flow. Studies by the San Francisco Estuary Institute ("SFEI") found that dissolved and total diazinon were directly correlated with flow in the Sacramento River, and dissolved and total DDTs and dieldrin were inversely correlated with flow in the San Joaquin River ($p<0.05$). However, no statistically significant relationships were found between flow and other organics including PAHs, PCBs, chlordanes, and chlorpyrifos in both rivers; diazinon in the San Joaquin River; and DDTs and dieldrin in the Sacramento River.[32] Therefore, the fact that delta smelt and longfin smelt abundance were directly proportional to flow in 1993 and 1994 is not evidence of no effect from organic contaminants.

F. Emergent Vegetation Should Be Classified As "C" For Toxics

Emergent vegetation is ranked as "0" for toxics, apparently because it "is unlikely to be affected by aquatic toxicant due to lack of exposure over long enough time scale." (Report, p. 5.) (Note that emergent vegetation is missing from the matrix and should be added.)

---

[31] Adams et al. 1995, pp. 60-61.

[32] SFEI, San Francisco Estuary Regional Monitoring Program for Trace Substances, 1994 Annual Report, 1996, Table 13.

This statement is unfounded and appears to be in error. The most commonly detected pesticide in both the Sacramento and San Joaquin Basins is an herbicide, simazine, which is detected 42 percent of the time at Sacramento and 80 percent of the time at Vernalis. Herbicides are designed to be toxic to plants. Pulses with concentrations up to 1.7 ug/L are present in the rivers for up to six months at a time.[33] This is certainly long enough to result in a toxic effect if the herbicide is toxic to emergent vegetation. Because nothing is known about the toxicity of simazine or any other commonly detected contaminant in the study area to emergent vegetation, emergent vegetation should be classified as "C."

G. The Support For the Classification of Phytoplankton Should Be Expanded

Phytoplankton are classified as "BC" because bioassays have shown toxicity on only "one occasion." (Report, p. 4.) Also, it is stated that there is no indication of toxic effects to phytoplankton. (Report, p. 11.) However, the data do not support these statements as described below.

The CVRWQCB has found that waters in the Sacramento Basin and Delta reduce the growth of Selenastrum capricornutum, a green alga, 11 to 22 percent of the time. In the Sacramento Basin between March 1988 and May 1990, significant growth impairment was found in 50 out of 227 samples, or 22 percent of the total. Samples collected in the Delta in this same study showed significant growth impairment in 11 out of 105 samples or 11 percent of the total.[34] Between February 1991 and September 1992, significant growth impairment was found in 16 out of 103 samples or 16 percent of the total.[35] Similarly, between April and July 1993, significant growth impairment was found in 8 percent of the samples. The discussion of phytoplankton should be expanded to discuss these studies.

---

[33] D. MacCoy, K.L. Crepeau, and K.M. Kuivila, Dissolved Pesticide Data for the San Joaquin River at Vernalis and the Sacramento River at Sacramento, California, 1991-94, USGS Open-File Report 95-110, 1995.

[34] Connor and Foe, December 1993.

[35] Connor and Deanovic, December 1994.

III. FOOD

A. Cladocera Should Be Classified As "0" For Food

Cladocera are classified as "A" for food because the "decline in 70s contemporaneous with reduction in organic loads from sewage treatment facilities suggestive of food limitation (fig 14 in Orsi and Mecum 1986) as well as CDFG testimony to SWRCB in 1987." (Report, p. 3.) This statement alone does not satisfy the condition for an "A" classification, which requires a "sufficient x-y relationship of some aspect of the factor and population abundance." (Report, p. 2.) As discussed below, a relationship has not been established between sewage loads and any biological indicator in the system.

I am not aware of any relationship between cladocera abundance and any aspect of food. The reference cited in the text, Figure 14 of Orsi and Mecum 1986, is a plot of cladocera abundance versus year, not food (e.g., organic loads, chlorophyll a concentration, or phytoplankton abundance). In fact, the very same paper shows that the x-y relationship between cladocera abundance and chlorophyll a concentrations has an r^2 of only 0.27 and is not statistically significant.[36] This would appear to be evidence for no effect of food on cladocera abundance and argues for classifying cladocera as "0" for food.

The Report concludes for both cladocera and rotifers that "sewage effect on contributed populations and food supply is likely responsible for long-term decline in abundance since 1970s" (Report, p. 11.), without presenting any supporting evidence. A relationship has not been established and is not likely to exist. This statement should be revisited based on the following discussion.

It is unlikely that a good x-y relationship would exist between cladocera and rotifer abundance and organic loads from municipal treatment plants. The Orsi and Mecum paper shows the decline in cladocera and rotifers was well underway in 1972.[37] In 1972, 62 percent of the total BOD5 from municipal sources upstream and within the Delta (7,325 ton/yr out of 11,836 ton/yr)

---

[36] J.J. Orsi and W.L. Mecum, Zooplankton Distribution and Abundance in the Sacramento-San Joaquin Delta in Relation to Certain Environmental Factors, Estuaries, v. 9, no. 4B, Table 14, Figure 16, and p. 337.

[37] Orsi and Mecum, 1986, Figure 14.

was discharged by the City of Sacramento.[38] Sacramento reduced its BOD5 discharge by about 20 percent (7,000 lb/day) in 1975 when the Central Treatment Plant was modified and in 1981 by an additional 50 percent (16,000 lb/day) when the Sacramento Regional Wastewater Treatment Plant came on-line.[39] Both of these reductions occurred long after the cladocera and rotifer decline was well underway. Most of the other smaller municipal dischargers, for example Stockton (548 tons/yr), did not reduce their BOD5 loads between 1970 and 1980, the period covered by Orsi and Mecum.

Finally, a plausible alternate explanation exists for the decline in cladocera. Many organochlorine pesticides, which are relatively nontoxic to cladocera, were banned in California in the 1970s and replaced by organophosphate pesticides, which are highly toxic to cladocera. For example, DDT was banned in 1972 and aldrin and dieldrin in 1974.

B. Several Species Ranked As "A" With No Evidence Of An x-y Relationship

The text ranks copepods, phytoplankton, and POC as "A," but presents no evidence that an x-y relationship exists between abundance and any aspect of food. For copepods, it is stated that "Eurytemora abundance peaks every summer whereas Psuedodiaptomus forbesi continues to be abundant suggesting a subtle but pervasive food limitation. Acartia in the South Bay responded in higher egg production to the spring bloom in 1993 whereas in Suisun Bay Acartia has undergone reduced summertime abundances since the arrival of Potamocorbula and P. forbesi." (Report, p. 2.) While this is evidence of individual cause-effect relationships, corresponding to a ranking of "B," it certainly does not constitute an x-y relationship between abundance and food.

For phytoplankton, it is admitted that nutrients, the food, are "rarely limiting except in infrequent bloom." Further, it is claimed that phytoplankton are light limited through turbidity and depth, both part of an organism's habitat. (Report, p. 3.) This would appear to be evidence for no effect from food, corresponding to a ranking of "0," rather than "A." Certainly,

---

[38] Bay Valley Consultants, Water Quality Control Plan for Sacramento, Sacramento-San Joaquin and San Joaquin Basins, 1974, Vol. II, Table 15-5.

[39] Personal communication between Mary James and Kurt Ohlinger, Sacramento Regional Wastewater Treatment Plant and Lyle Hoag, February 5, 1994.

neither of these claims constitute an x-y relationship between food and phytoplankton.

Finally, the discussion of POC is irrelevant. (Report, p. 3.) Food cannot be limiting for POC because POC is food. This item in the matrix should be left blank. In fact, POC is not a species and would be more appropriately dealt with as a component of habitat.

IV. HABITAT

A. The Role Of Habitat In Delta Smelt Abundance Has Been Misclassified

Delta smelt are classified as "A" for habitat. Habitat is also ranked as the number 1 factor controlling delta smelt abundance. Both of these classifications are contradicted by the evidence. Delta smelt is ranked "A" because their "abundance varies in relation to number of days when their preferred salinity zone is located within Suisun Bay," suggesting "a direct impact of habitat on successful rearing." (Report, p. 7.) This reported relationship is not only weak, but "counter-examples" exist, which are not allowed by factor "A."

First, the referenced x-y relationship, which is between the midwater trawl delta smelt index and the number of days when X2 is in Suisun Bay between February and June, is very weak, accounting for only 25 percent of the variability in the data ($r^2 = 0.25$, $p<0.005$).[40] As discussed in Comment IA, this means that the majority of the variability in delta smelt abundance (75%) is due to factors other than habitat. In spite of this extremely weak correlation, habitat was ranked as the number 1 factor controlling delta smelt abundance. This is contrary to the evidence. It would appear that for delta smelt, that we either do not know what is controlling abundance or that abundance is controlled by a large number of factors acting simultaneously. In either case, it is misleading to conclude that habitat limits delta smelt abundance.

Second, there is contrary evidence, or so-called "counter-examples." Herbold's analysis does not take into account the substantial nonuniform variance in the data. The variance in the delta smelt abundance index directly increases as the average abundance index increases. When Herbold's analysis is repeated,

---

[40] B. Herbold, Memorandum to Delta Smelt Workgroup Re: Relationship of Delta Smelt to EPA Estuarine Standard, November 14, 1993 and B. Herbold, Habitat Requirements of Delta Smelt, IESP Newsletter, Winter 1994, pp. 1-3.

taking into account this variance (i.e., using weighted least squares regression with the weights inversely proportional to the variance), the resulting relationship accounts for only 2 percent of the variability and is not statistically significant.[41] Furthermore, both Fox and Britton[42] and Jassby and others[43] failed to find any relationship whatsoever between delta smelt abundance and X2.

B. The Role Of Habitat In Copepod Abundance Has Been Misclassified

Copepods are classified as "A" in the entrapment zone, apparently because "entrapment zone species of copepods respond in a fashion similar to Neomysis." (Report, p. 7.) No evidence is presented to support this claim. While it is true that Neomysis and Eurytemora affinis, a common copepod in the estuary, respond similarly to salinity in the entrapment zone,[44] this does not mean that there is a "sufficient x-y relationship" between copepod abundance in the entrapment zone and any habitat variable. In fact, no evidence of an x-y relationship was presented, and the available data suggest that none exists.

A comparison of log abundance time series plots for Neomysis and Eurytemora in the entrapment zone indicate that the abundance of these two species is not related.[45] Therefore, it is unlikely that any habitat variable would correlate with both of them. In fact, Jassby and others found a good relationship between X2 and the abundance of Neomysis in Suisun Bay and the Delta (r^2=0.62), but no relationship between Eurytemora abundance and X2.[46] The lack of any relationship between Eurytemora abundance and X2, a habitat surrogate, is evidence that habitat has no effect on copepod abundance. Therefore, habitat for

---

[41] J.P. Fox and A.S. Britton, Evaluation of the Relationship between Biological Indicators and the Position of X2, Draft CUWA Report, March 7, 1994, pp. 10-12.

[42] Fox and Britton 1994, Table 3.

[43] Jassby et al. 1995, Figure 6.

[44] W. Kimmerer, An Evaluation of Existing Data in the Entrapment Zone of the San Francisco Bay Estuary, IESP Technical Report 33, September 1992, pp. 26-27.

[45] Kimmerer, 1992, Figures 38 and 41.

[46] Jassby et al. 1995, Table 2 and Figure 6.

copepods should be classified as "0" as this is evidence for no effect.

Copepods are also classified as "B" elsewhere, apparently because "abundance of individual species of copepods in delta may depend on residence time or flow rates." Orsi and Mecum found no relationship between copepods, or any other zooplankton taxon and net velocity.[47] Therefore, habit for copepods should be classified as "0" as this is evidence for no effect.

C. The Role Of Habitat In American Shad Abundance Has Been Overstated.

American shad are classified as "A" for habitat, apparently because Stevens and Miller 1983 reported that flow is correlated with abundance. (Report, p. 7.) Although the correlation that they reported is excellent ($r^2 = 0.86$, $p<0.01$ for April flows), it is only for the period 1967 to 1978.[48] When the entire period of record, 1967 to 1992, is correlated against X2, the resulting relationship is still statistically significant, but accounts for only 36 percent of the variability.[49] This is a very weak relationship, and, as discussed in Comment IB, suggests that habitat for American shad should be classified as "AB" rather than "A."

D. Threadfin Shad Should Be Classified As "0" for Habitat

Threadfin shad was classified as "C" for habitat because they "have been little studied in this estuary." (Report, p. 8.) However, Fox and Britton reported that there is no relationship between threadfin shad and X2.[50] This is evidence that habitat has no effect on threadfin shad abundance. Therefore, threadfin shad should be classified as "0" for habitat.

---

[47] Orsi and Mecum 1986, p. 337.

[48] D.E. Stevens and L.W. Miller, Effects of River Flow on Abundance of Young Chinook Salmon, American Shad, Longfin Smelt, and Delta Smelt in the Sacramento-San Joaquin River, North American Journal of Fisheries Management, v. 3, 1983, Table 5.

[49] Fox 1994, Table 3.

[50] Fox and Britton, 1994, Table 3.

E. Longfin Smelt Should Be Classified As "AB" for Habitat

Longfin smelt was classified as "A" for habitat because they have a "strong relationship with X2 location." (Report, p. 7.) Jassby and others reported that X2 accounted for 79 percent of the variability in longfin smelt abundance.[51] However, there were a number of problems with Jassby's analyses, including the use of outdated abundance indices, the omission of two years (1967, 1983), and the use of an inaccurate variance assumption. When these shortcomings are corrected, X2 accounts for only 27 percent of the variability in longfin smelt abundance.[52] This is a weak relationship, and based on the discussion in Comment IB, longfin smelt should be classified as "AB" for habitat. Further, the statement on page 9 that "strong connection to X2 suggests that non-flow related parameters are unlikely to affect abundance" should be revisited.

V. ENTRAINMENT

A. Delta Smelt Are Misclassified For Entrainment

Delta smelt are classified as "AB" for entrainment because the "entrainment index is high when population is low." (Report, p. 5.) However, the correlation of CVP and SWP salvage for 1979 to 1991 with delta smelt abundance indicates the reverse, namely that salvage is high when abundance is high. Further, the relationship is not statistically significant, and only accounts for 8 percent of the variability in the data. Therefore, it is unlikely that entrainment has a "probable population-level effect" on delta smelt. Entrainment of delta smelt should be reclassified as "C" or "0."

B. Phytoplankton And POC Are Misclassified For Entrainment

Phytoplankton and POC are classified as "A" for entrainment because they were "described more successfully by models incorporating entrainment than by X2 alone (Jassby et al. 1993)." (Report, p. 5.) This rationale is incorrect. Jassby et al. 1993 did not model phytoplankton at all. They also did not include entrainment in the model that was fit to POC.[53] However, Jassby et al. 1994 found that diversions and Delta outflow together account for 86 percent of the variability in median chlorophyll a

[51] Jassby et al. 1993, Table 2.

[52] Fox and Britton, 1994, pp. 13-17.

[53] Jassby et al. 1993, p. 281.

concentrations in the summer in the entrapment zone. They also reported that San Joaquin River flow and exports account for 63 percent of the variability in annual chlorophyll a concentrations at station P12 in the lower San Joaquin River.[54] The relative contribution of flow and diversions to the variability of chlorophyll a concentrations cannot be separated based on this work.

However, based on these results, POC should be classified as "C" for entrainment because there are no x-y relationships between POC and diversions. Further, phytoplankton should be narrowly classified as "A" in the lower San Joaquin River and in the entrapment zone only in the summer because the relationship has not been demonstrated elsewhere.

[54] A.D. Jassby and T.M. Powell, Hydrodynamic Influences on Interannual Chlorophyll Variability in an Estuary: Upper San Francisco Bay-Delta (California, U.S.A.), Estuarine, Coastal and Shelf Science, v. 39, no. 6, 1994, pp. 595-618.